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(71) Applicant *(for all designated States except US)*: BRITISH TECHNOLOGY GROUP LIMITED [GB/GB]; 101 Newington Causeway, London SE1 6BU (GB).

(72) Inventor; and

(75) Inventor/Applicant *(for US only)*: CLAYDEN, David, Oswald [GB/GB]; 305 Jersey Road, Isleworth, Middlesex TW7 5PH (GB).

(74) Agent: CULLIS, Roger; Patents Department, British Technology Group Limited, 101 Newington Causeway, London SE1 6BU (GB).

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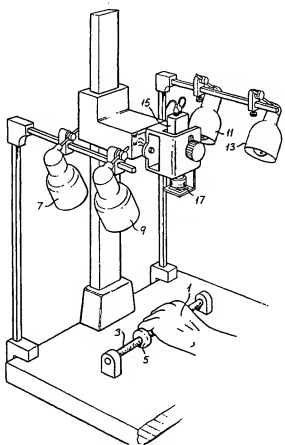
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: BIOMETRIC IDENTIFICATION OF INDIVIDUALS

(57) Abstract

A method of verifying the identity of an individual comprises capturing an image of the subcutaneous vein pattern at a predetermined region of the individual, converting the captured image to a plurality of stored values representative of the intensity of said image at specified relative locations, processing the stored values to produce a second plurality of stored values representative of the image of the vein pattern having enhanced contrats and subjecting the second plurality of stored values to a thresholding process to select those above a predetermined value and storing a set of measurements derived from the selected ones of said second plurality of stored values for comparison with a corresponding set of measurements made on the individual.



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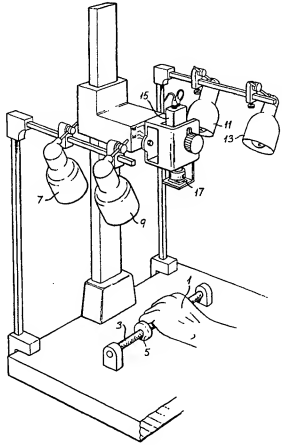

Biometric identification of individuals

This invention relates to the biometric identification of individuals and, in particular, to methods and apparatus for detecting the locations of subcutaneous blood vessels and for encoding such locations for storage on identity cards. It finds particular application in the verification of identity in transactions involving such cards.

In this specification, the expression "vein pattern" is deemed to include the pattern of arteries, capillaries and other blood vessels.

In British Patent No. 2156127 there is described a method and apparatus for the identification of individuals by means of subcutaneous patterns of blood vessels. One difficulty encountered with such apparatus is the poor signal-to-noise ratio when endeavouring to detect blood vessel locations, for example, in the back of the hand. This may be due to hairs, or the non-planar nature of the locations or uneven illumination.

We have now devised an improved method of verifying the identity of individuals. According to the present invention there is provided a method of verifying the identity of an individual comprising the steps of capturing an image of the subcutaneous vein pattern at a predetermined region of the individual, converting said captured image to a plurality of stored values representative of the intensity of said image at specified relative locations, processing said stored values to produce a second plurality of stored values representative of an image of said vein pattern having enhanced contrast and subjecting said second plurality of stored values to a thresholding process to select those above a predetermined value and storing a set of measurements derived from the selected ones of said second plurality of stored values for comparison with a corresponding set of measurements made on said individual.

The invention will be particularly described with reference to the accompanying drawings, in which:-

Figure 1 is a perspective view of apparatus suitable for scanning vein patterns;

Figure 2 is a block diagram of apparatus in accordance with a preferred embodiment of the invention;

Figure 3 shows a raw vein pattern obtained from the apparatus of Figure 2;

Figure 4 shows the image of Figure 3 after processing to enhance its contrast;

Figure 5 shows the image of Figure 4 after processing to reveal boundary lines;

Figure 6 shows a pattern of vectors imposed on the image of Figure 5;

Figure 7 shows two superimposed vein patterns;

Figure 8 shows the vein patterns after alignment;

Figure 9 shows the matched portions of the two superimposed patterns; and

Figure 10 shows the mismatched portions of the vein patterns.

Referring now to the drawings, a hand 1 of an individual whose identity is to be verified is positioned approximately by gripping a positional reference handle 3. An optional side stop 5, against which the side of the hand abuts, provides an additional constraint. Even illumination is provided by four laterally-positioned incandescent lamps 7,9,11,13 which are under-run to provide an infra-red-rich emission spectrum. A video camera 15 is positioned directly above the hand position and produces a raster-scan image of the back of the hand. A band-pass filter 17 extracts an infra-red image and reduces the proportion of visible radiation. It therefore enhances the visibility of the subcutaneous vein pattern.

By viewing the vein pattern through a pair of filters having different transmission characteristics, it is possible to differentiate between veins and arteries, which have different relative contents of oxy-haemoglobin and carboxy-haemoglobin. This may be used as a basis for enhanced recognition tests or simply to verify that the hand is still attached and vital.

The two images may be obtained sequentially by substituting one filter for the other or simultaneously by means of a split image with one filter in each field of view.

Referring to Figure 2, the output of the video camera 100 is transferred to a frame store 101. The raw image from the video camera suffers from poor contrast and also from the effects of varying brightness across its width, due to the curved nature of the back of the hand.

During a first signal processing step in signal processor 102, the amplitude of each pixel is weighted to enhance the local contrast. The contrast can be improved by employing a local contrast enhancement function, making use of the values at sampling points in the neighbourhood of each point in the plane. In general, the design of a local contrast enhancement function is a compromise between performance and speed. The particular function chosen in the preferred embodiment is a single-dimensional one employing six points in a line transverse to the axis of the hand. The amplitude at a particular point is derived from the sum of the amplitudes of the two immediately-adjacent pixels and the pixels at a distance of ±10 and ±20 pixels therefrom. The immediate neighbouring pixels are given a weighting factor of +2 and the amplitudes of the pixels at ±10 and ±20 pixels spacing are given a weighting factor of -1. The sum of these six weighted values is then taken to give a net value for each position. The effect of this weighting regime is to produce a blood vessel pattern with an enhancement of the longitudinal (in the direction L) blood vessels at the expense of the transverse ones (in the direction T). This image is subjected to a thresholding process in a threshold detector 103 to produce a black and white pattern. (Figure 3)

The black and white image is also preferably subjected to an area thresholding process to remove small white artifacts in the black regions and small black objects in the white regions. (Figure 4)

We have found that, in practice, there is sufficient information content in the longitudinal blood vessels to permit adequate identification to be performed and that the attenuated image of the transverse blood vessels is not disadvantageous. On the other hand, this step reduces the demands placed on the data handling and storage requirements of the system.

The cleaned-up black and white image of the blood vessel is then converted in a further signal processor 104 to a series of vectors, which are a series of small straight lines approximating to the centre line of each blood vessel. These vectors may be used for various purposes (a) to measure misalignment of one image relative to another, both rotationally and longitudinal and lateral displacement (b) to obtain a score for the probability that the two compared images are of the same blood vessel pattern and (c) to provide compressed data description of a vein pattern which can be used as a reference template. They are stored in an output device 105.

The transverse resolution of the video camera is five hundred and twelve pixels, of which about two thirds occur in the width of the hand - there is a gap at either side - equivalent to about four hundred pixels across the hand. Longitudinally, it is 128 lines. The width of a vein is typically about two millimetres.

An objective of the signal processing is to improve the signal-to-noise ratio so that spurious results will not, for example be caused by hairs on the back of the hand.

Signal-to-noise ratio is enhanced by the weighting regime adopted.

A variety of methods may be used for measuring the similarity of two vein patterns.

The first method involves measuring the area of patterns which coincide (performing a logical AND on the two vein patterns). (Figure 9) this is divided by the area of the non-coinciding part of the patterns (Logical XOR) (Figure 9) Typical results for a pair of well aligned pair of patterns

taken from the same hand at different times is 1.5, whilst the best an imposter can achieve is about 0.25.

A second method involves measuring the total length of vein centre-line which falls within a pre-determined tolerance of the centre-line of the other image.

By using a compressed template and a test pattern, after alignment a score can be calculated by counting the number of vector ends (or vector centres) which fall within (or close to) the outline of the test pattern. The ratio of these two values will give a score similar to that of method 1.

Method 4 involves using a compressed template and the centre-lines of a test pattern. The test is set by the length of centreline which falls within a predetermined tolerance of the vectors of the template.

A fifth method uses two sets of vectors and integrates the misalignment of the vector ends of one pattern and the vectors of the other pattern.

Claims

1. A method of verifying the identity of an individual comprising the steps of capturing an image of the subcutaneous vein pattern at a predetermined region of the individual, converting said captured image to a plurality of stored values representative of the intensity of said image at specified relative locations characterised in that it further includes the steps of processing said stored values to produce a second plurality of stored values representative of an image of said vein pattern having enhanced contrast and subjecting said second plurality of stored values to a thresholding process to select those above a predetermined value and storing a set of measurements derived from the selected ones of said second plurality of stored values for comparison with a corresponding set of measurements made on said individual.

2. A method of verifying the identity of individuals according to claim 1 characterised in that the step of processing the stored values to produce a second plurality of stored values representative of an image having enhanced contrast comprises determining a mean of measurements taken at a given point and predetermined points on opposite sides of said point weighted to give greater effect to the measurement taken at the given point.

3. A method of verifying the identity of individuals according to claim 2 characterised in that a value in said second plurality is determined by measuring a first pair of amplitudes at pixels on either side of a given point, a second pair of amplitudes at ten pixels on either side of said given point and a third pair of amplitudes at twenty pixels on either side of said point and said first pair of amplitudes is given a wieghting of 2 and said second and third pair of amplitudes is given a weighting of -1.

4. A method of verifying the identity of individuals according to any one of the preceding claims including the step of further processing said second plurality of stored values to remove those corresponding to small area artifacts in said vein pattern.

5. A method of verifying the identity of individuals according to any one of the preceding claims characterised in that the method of comparison comprises measuring the area of patterns which coincide and dividing this measurement by the area of the non-coinciding part of the patterns.

6. A method of verifying the identity of individuals according to claim 5 characterised in that the acceptance/rejection threshold is a ratio of 1.

7. A method of verifying the identity of individuals according to claim 6 characterised in that the acceptance threshold is a ratio of 1.5.

8. A method of verifying the identity of individuals according to claim 6 characterised in that the rejection threshold is a ratio of 0.25

9. A method of verifying the identity of individuals according to any one of the preceding claims 1 to 5 characterised in that the method of comparison comprises measuring the total length of vein centre-line which falls within a pre-determined tolerance of the centre-line of the other image.

10. A method of verifying the identity of individuals according to any one of the preceding claims 1 to 5 characterised in that the method of comparison comprises using a compressed template and a test pattern, after alignment calculating a score by counting the number of a predetermined part of a vector which fall within the outline of the test pattern.

11. A method of verifying the identity of individuals according to any one of the preceding claims 1 to 5 characterised in that the method of comparison comprises using a compressed template and a test pattern, after alignment calculating a score by measuring the length of centreline which falls within a predetermined tolerance of the vectors of the template.

12. A method of verifying the identity of individuals according to any one of the preceding claims 1 to 5 characterised in that the method of comparison comprises using two sets of vectors and integrating the misalignment of the vector ends of one pattern and the vectors of the other pattern.

13. Apparatus for verification of the identity of an individual comprising means 100 for capturing an image of the subcutaneous pattern of veins at a predetermined region of the individual and to derive a signal corresponding to said image, means 101 to enhance the contrast of said signal and detector means 102 to detect signals in excess of a predetermined threshold.

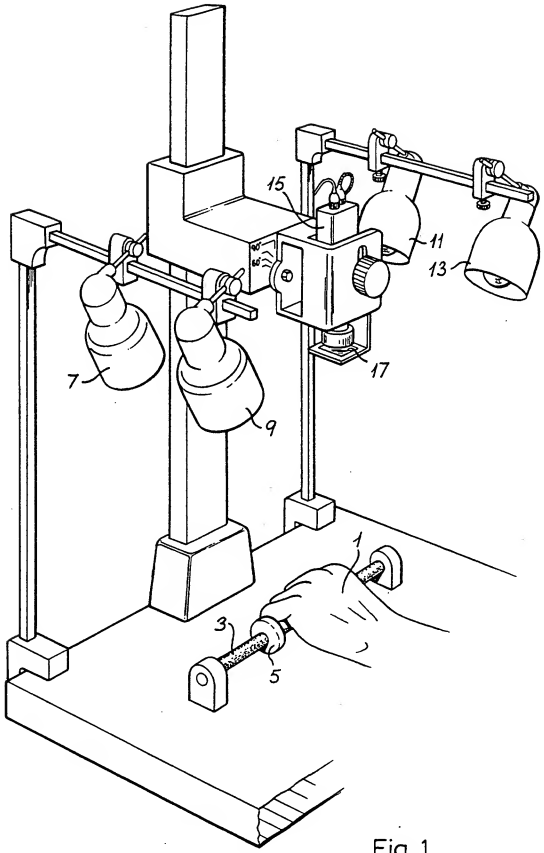

Fig.1

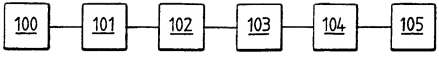

Fig. 2

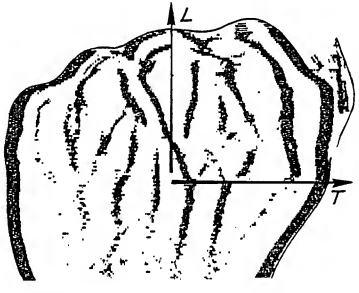

Fig. 3

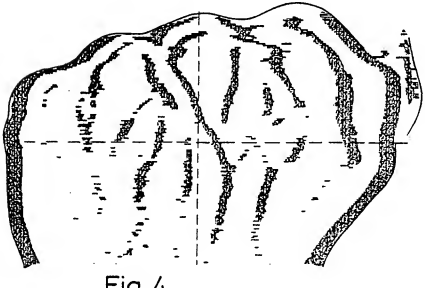

Fig. 4

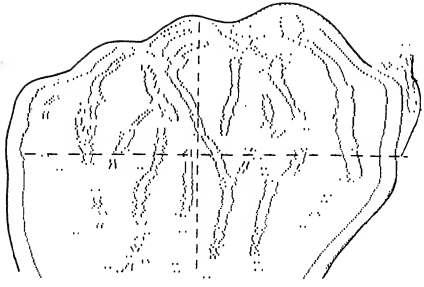

Fig. 5

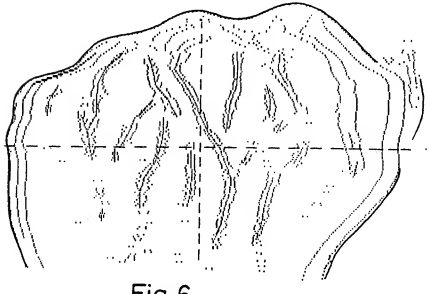

Fig. 6

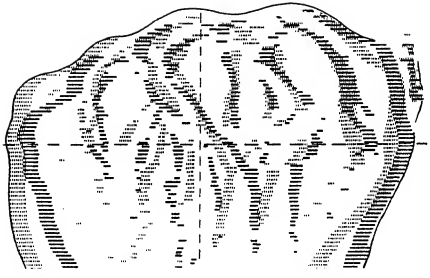

Fig.7

Fig.8

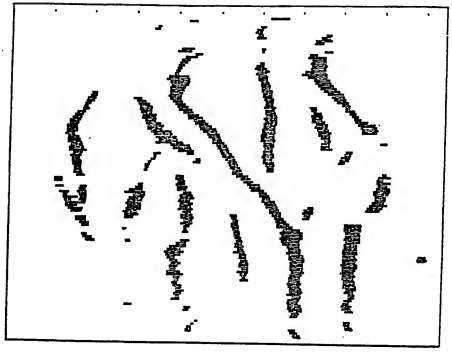

Fig.9

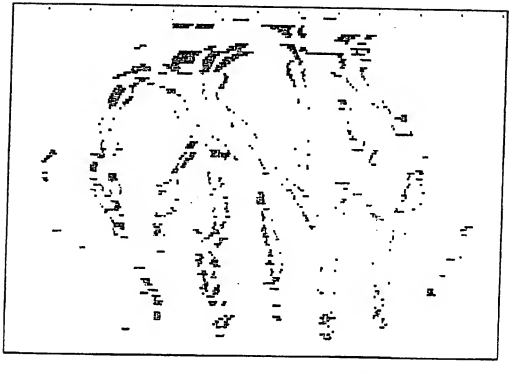

Fig.10

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 A61B5/117

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 A61B G07C G06K G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO,A,88 04153 (KODAK LIMITED) 16 June 1988 see page 4, line 13 - page 6, line 24 see figures ---	1
Y	US,A,4 811 414 (FISHBINE ET AL.) 7 March 1989 see column 6, line 9 - line 52 see column 15, line 6 - column 17, line 53 see column 23, line 21 - column 25, line 4 see figures 1,20-22,28-30	1
A	-----	2-4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 July 1994	31. 08. 94
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax (+31-70) 340-3016	Authorized officer Chen, A

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INTERNATIONAL SEARCH REPORT

information on patent family members

Inter nal Application No
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
WO-A-8804153	16-06-88	AU-A-	8329687	30-06-88
		EP-A-	0333741	27-09-89
		JP-T-	1503203	02-11-89
US-A-4811414	07-03-89	NONE		